

## BLAST HOLE LINER SYSTEM AND METHOD FOR THE SAME

### BACKGROUND OF THE INVENTION

#### 5        Field of the Invention

The present invention relates generally to blast hole liners. More particularly, the present invention relates to a method for installing a tubular liner and a blast hole liner system associated with the method.

#### State of the Art

10        In the mining industry where the mineral lies substantially below ground level, blast holes are bored for receiving explosive material. Detonating the explosive material breaks up the hard material surrounding the holes. An ammonium nitrate-fuel oil mixture (commonly known as "ANFO") is often employed as the explosive material. Moisture from rain or ground water sources has a deleterious effect upon the explosive  
15        material, which has resulted in the common practice to insert waterproof plastic liners in the blast holes for holding the explosive material.

One common method of placing the plastic liner in a blast hole is to have the liner rolled on a tube with a sealed end of the liner on the outside of the roll. The liner commonly has a pocket formed below the sealed end. This pocket is loaded with drill  
20        cuttings or some other weighted material. The weighted end of the liner is placed into the top of the blast hole and a rod is placed through the center of the tube to act as an axle. The weighted end pulls the liner axially down the hole as the liner unrolls from the tube until the weighted end reaches the bottom of the blast hole. The excess liner remaining on the roll is then cut off and the liner in the blast hole is secured to a holder  
25        or to the explosive loading equipment.

Although this method has become accepted and common practice, there are at least two serious disadvantages resulting in this method. First, as the liner slides axially down the blast hole, the liner is subjected to abrasion and/or tearing by sharp rock points and edges. This is especially severe when the liner is being placed in an inclined blast  
30        hole. Second, the pocket end of the liner that rests on the bottom of the blast hole is a temporary support for the free-flowing bulk explosive product that is loaded into the liner. The weight of the explosive material poured in the liner is normally hundreds to even thousands of pounds, which expands the liner against the wall of the blast hole.

The explosive material's weight pushes into the sealed end of the liner down around the pocket, placing tension stress on the sealed end of the liner often causing the sealed end to open or tear. Further, such weight moves the liner wall axially against the sharp rocks often causing punctures in the liner wall. Failure in the sealed end and along the liner wall often results in water contacting the explosive material causing the explosive material to become undetonatable.

Some liner designs attempt to protect the lower portion of the liner by covering the liner with an abrasion resistant woven sleeve of plastic or fabric. This is helpful, but imperfect, because the liner still comes to rest on the weighted pocket below the seal placed in tension when receiving the immense weight of the explosive material. Further, the rougher fabric sleeve sometimes prevents the liner from reaching the bottom of inclined muddy blast holes.

Field research has been conducted with such abrasive resistant liners to evaluate water entry into the liners loaded with the explosive material. For example, in a group of twenty-four muddy blast holes each having a twenty-five degree incline, a twelve inch diameter and a 160 foot length, liners with 20 foot long protective woven plastic sleeves on the bottom were loaded into the twenty-four blast holes along with explosive material in the manner previously described. Resistance probes were then placed inside the bottom ends of each of the liners. At various times between eight hours and eight days after initial loading, the resistance probe readings indicated that water entered the bottom parts of at least eighteen of the twenty-four liners.

Another imperfect method of attempting to prevent settling, stretching, and tearing of the liner is to place an inflating plug in the bottom of the liner to lock the liner in place against the walls of the blast hole. This inflating plug is a two component urethane foam device or a bag inflated with compressed gas. This is an inadequate method because of the time delay and the uncertainty of the inflation. Also, if the blast hole wall is coated with mud the inflated plug may not be able to resist the weight of as much as 8,000 pounds of explosive material loaded above the plug. Further, the liner is still subjected to tearing as the liner is slid axially into the blast hole.

Accordingly, it would be advantageous to develop a method and system that limits the potential of tearing or puncturing liners when positioned in blast holes and during the process of loading the liners with explosive material.

**SUMMARY OF THE INVENTION**

The present invention relates to a method and apparatus providing a blast hole sealing system configured to substantially seal explosive material in a blast hole from moisture. The blast hole sealing system includes a securing structure, a cap member, a tubular liner and an air compressor. The securing structure is operable to be disposed over an upper portion of the blast hole. The cap member defines a nozzle opening and a liner passage therein and is operable to attach to a top portion of the securing structure. The tubular liner includes an unexpanded configuration having a length with an openable-expandable end and a sealed tail end. The openable-expandable end is operable to be disposed through the liner passage in the cap member so that an end portion disposed therethrough is invertedly opened in an expanded configuration and operatively secured to the securing structure. The air compressor is operatively coupled to the cap member and operable to compress air through the nozzle opening in the cap member against the expanded configuration of the tubular liner to invertedly expand and progressively advance the tubular liner into the blast hole with radial expanding movement of the tubular liner along a wall length of the blast hole. The air compressor is operable to invertedly expand the tubular liner against the wall length of the blast hole so that the sealed tail end is disposed at a lower portion of the blast hole within the expanded configuration of the tubular liner. With this arrangement, the tubular liner is operable to receive the explosive material and seal the explosive material from moisture in the blast hole.

Additional features and advantages of the invention will be apparent from the detailed description which follows, taken in conjunction with the accompanying drawings, which together illustrate, by way of example, features of the invention.

**BRIEF DESCRIPTION OF THE DRAWINGS**

FIG. 1 illustrates a cross-sectional side view of a blast hole sealing system, depicting an unexpanded tubular liner expanded at an end portion thereof and inverted around a tubular structure at a top of a blast hole, according to an embodiment of the invention;

FIG. 1(a) illustrates a side view of another embodiment of the tubular structure having a conical portion;

FIG. 1(b) illustrates a partial perspective view of the tubular liner, depicting an open end and the sealed tail end of the tubular liner;

FIG. 2 illustrates a top view of a cap member configured to be disposed over the tubular structure;

FIG. 3 illustrates a cross-sectional view taken along line 3 in FIG. 1, depicting the tubular liner in the unexpanded form disposed within the securing structure;

FIG. 4 illustrates a cross-sectional side view of the blast hole sealing system, depicting the tubular liner in a substantially expanded position lining the blast hole except for at a lower portion of the blast hole a portion of the liner maintains the unexpanded position; and

FIG. 5 illustrates a cross-sectional side view of the lower portion of the blast hole, depicting the tubular liner expanding at the end portion thereof by adjusting to the weight of explosive material placed within the liner.

## **DETAILED DESCRIPTION**

Reference will now be made to the exemplary embodiments illustrated in the drawings, and specific language will be used herein to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended. Alterations and further modifications of the inventive features illustrated herein, and additional applications of the principles of the inventions as illustrated herein, which would occur to one skilled in the relevant art and having possession of this disclosure, are to be considered within the scope of the invention.

FIG. 1 illustrates a blast hole sealing system 100 configured to position a tubular liner 150 into a blast hole 10 prior to disposing explosive material (not shown) in the tubular liner 150 and sealing the explosive material from the natural elements, such as moisture, within the blast hole 10. The blast hole 10 typically includes, but is not limited to, a diameter of approximately eight inches to twelve inches and extends a length of approximately 50 feet to 200 feet. The blast hole 10 includes a blast hole wall 16 extending along and between an upper portion 18 and a lower portion 20 of the blast hole 10.

Such a blast hole sealing system 100 can include, among other things, a securing structure 110, a cap member 120, an air compressor 130, an air-relief pipe 140 and a tubular liner 150. The blast hole sealing system 100 is configured to blow air into the

tubular liner 150 down into the blast hole 10 so that the tubular liner 150 is blown inside-out or inverted into the blast hole 10. In this manner, the tubular liner 150 is substantially limited in axial movement against a blast hole wall 16. Specifically, the tubular liner 150 advances deeper into the blast hole 10 by expanding against the blast hole wall 16 with radial expanding movement progressively within and along the length of the blast hole wall 16 to, thereby, substantially limit axial movement against the blast hole wall 16 and thus, limit potentially puncturing the tubular liner 150. Although the drawing figures depicted herein illustrate the blast hole 10 extending vertically downward, it can be well appreciated by one of ordinary skill in the art that the tubular liner can be installed in blast holes oriented at various angles, such as at an angle up to at least approximately 30 degrees from the vertical.

The securing structure 110 can be at least partially a cylindrical type structure defining an inner surface 112 and an outer surface 114 with opposite open ends. The securing structure 110 can include a diameter sized so that a lower portion 116 of the securing structure 110 can be positioned within the upper portion 18 of the blast hole 10 and an upper portion 118 of the securing structure 110 can be exposed above the blast hole 10. Such a securing structure 110 is configured to secure the tubular liner 150 thereto and, once the liner 150 is positioned in the blast hole 10, the securing structure 110 can act as a funnel for pouring and/or placing the explosive material (not shown) in the blast hole 10. The securing structure 110 can be formed from any suitable material or combination of materials, such as steel, aluminum, or alloys thereof, or a suitable high-strength polymeric material, or any other suitable material known to one of ordinary skill in the art.

In another embodiment, the lower portion 216 of the securing structure 210 can include a conical portion 215 configured to be disposed in the upper portion 18 of the blast hole 10, as depicted in FIG. 1(a). Such a conical shaped securing structure 210 can also be conical at an upper portion 218 (shown in outline) thereof to facilitate pouring the explosive material (not shown) into the blast hole 10.

With reference to FIGS. 1 and 2, the cap member 120 can be sized and configured to be disposed over the upper portion 118 of the securing structure 110. In particular, the cap member 120 can include a cap securing portion 122 configured to attach to the upper portion 118 of the securing structure 110 via clamps and/or rotatably fastening the cap member thereto. Such a cap member 120 can include a nozzle opening

124 and a liner passage 126. The nozzle opening 124 is configured to receive a nozzle 132 coupled to the air compressor 130 for blowing or compressing air through the nozzle opening 124 and through the inside of the cylindrical securing structure 110. The liner passage 126 is an opening defined through the cap member 120 which is sized and  
5 configured to facilitate passage of the tubular liner 150 therethrough in an unexpanded configuration 154 (FIG. 3). The cap member 120 can also include handles 128 to assist in manually attaching and removing the cap member 120 to the securing structure 110. The cap member 120 can be formed from any suitable material or combination of materials, such as aluminum, steel, or alloys thereof, or a high-strength polymeric  
10 material, or any other suitable material known to one of ordinary skill in the art.

Referring to FIGS. 1 and 3, the air-relief pipe 140 includes a tube-like structure defining an inner passage 148 extending along a longitudinal length between two opposite open ends of the air-relief pipe 140. Such an air-relief pipe 140 is configured to be disposed within the blast hole 10 and extend at least the length of the blast hole 10.

15 The air-relief pipe 140 includes an exposed end portion 142 and a perforated end portion 144. The perforated end portion 144 is configured to be disposed at a lower portion 20 of the blast hole 10 while the exposed end portion 142 is configured to extend out and above the upper portion 18 of the blast hole 10. The perforated end portion 144 includes multiple openings 146 extending through the air-relief pipe 140 to the inner passage 148  
20 to facilitate air to displace from the blast hole 10 through the inner passage and out the exposed end portion 142 of the air-relief pipe 140 as the tubular liner 150 advances into the blast hole 10. Due to water 22 settling in the bottom of the blast hole 10, the perforated end portion 144 can span along the air-relief pipe 140 at least one foot and up to approximately twenty feet, or any suitable distance to ensure that at least some of the  
25 multiple openings 146 will be exposed from the settling water 22 for air to displace therethrough as the tubular liner 150 advances down the blast hole 10. Such an air-relief pipe 140 can be formed as a single rigid pipe or multiple telescoping rigid pipes and/or a rigid pipe interconnected with a flexible hose-type pipe or any other suitable pipe known to one of ordinary skill in the art. The air-relief pipe can be formed from metallic  
30 materials, such as steel, aluminum and/or alloys thereof or a polymeric-type material or any other suitable material known in the art.

With reference to FIGS. 1 and 1(b), the tubular liner 150 is sized and configured to expand in an expanded configuration 152 into the blast hole 10. Prior to such

expansion, the tubular liner 150 is in an unexpanded configuration 154 and typically will be rolled up in a liner roll 160. The tubular liner 150 can include an open end 156 and a sealed tail end 158 with a diameter, in the expanded configuration, slightly larger than the diameter of the blast hole 10. For example, for blast holes 10 having a diameter of approximately twelve inches, the tubular liner 150 can include a diameter of approximately thirteen inches. The sealed tail end 158 of the tubular liner 150 can be formed by any suitable method of sealing to maintain the unexpanded configuration 154 at the end of the tubular liner 150, such as by heat sealing, clamping and/or twisting the tail end 158. The tubular liner 150 includes a predetermined length between approximately five feet to thirty feet longer than the length of the blast hole 10. Such a tubular liner 150 can be formed from an inexpensive material, such as any suitable polymeric-type material, for example, linear low density polyethylene, or any other suitable polymeric-type material that yields or stretches without readily puncturing and tearing as known to one of ordinary skill in the art.

As previously set forth, the tubular liner 150 can be rolled up in the form of a liner roll 160. Such a liner roll 160 can be rolled around, for example, a tubular member 164 that can be loosely mated with a roller shaft 172 extending from a roller stand 170. The roller stand 170 can be free-standing on legs 174 so that the liner roll 160 can be positioned over the cap member 120. In another embodiment, the roller stand 170 can be coupled to the securing structure 110 and/or the cap member 120. In either case, the roller stand 170 is positioned so that the roller shaft 172 of the roller stand 170 holds the liner roll 160 over the cap member 120.

With respect to FIGS. 1, 1(b) and 2, prior to installing the tubular liner 150 in the blast hole 10, a portion of the tubular liner 150 can be rolled-out from the liner roll 160, inserted through the liner passage 126 of the cap member 120, and then through the inside of the cylindrical securing structure 110. The open end 156 can then be opened-up into the expanded configuration and invertedly pulled around the lower portion 116 of the securing structure 110 and then pulled upward around the outer surface 114 of the securing structure 110. The tubular liner 150 can then be secured to the outer surface 114 of the securing structure 110 with clamps, adhesive tape and/or bungee cord or secured by fastening the cap member 120 over a portion of the tubular liner 150, or any other suitable method of securing the open end 156 of the tubular liner 150 to the securing structure 110.

One of ordinary skill in the art can well appreciate that other methods can also be employed to invertedly position and secure the open end to the securing structure 110. For example, the open end 156 can be inserted through the liner passage 126 in the cap member 120 and then opened-up into the expanded configuration and then pulled around the outer surface 114 of the upper portion 118 of the securing structure 110. A portion of the tubular liner 150 can then be manually pushed through the inside of the securing structure 110, after which, the cap member 120 can be attached to the upper portion 118 of the securing structure 110. Furthermore, in another embodiment, the open end 156 can be inserted through the liner passage 126 defined in the cap member 120, then opened-up into the expanded configuration and then pulled around a bottom surface of the cap member 120 and attached to, for example, the periphery of the cap member 120. The cap member 120 can then be attached to the securing structure 110 with a portion of the tubular liner 150 therebetween. In this manner, other methods can be employed to position and operatively secure the tubular liner 150 to the securing structure 110 to facilitate blowing air into the expanded configuration of the tubular liner 150 for advancing the tubular liner 150 into the blast hole 10 in an inside-out or inverted manner.

With reference to FIG. 1, prior to positioning the securing structure 110 over the blast hole 10, the air-relief pipe 140 can be placed in the blast hole 10 in the orientation as previously set forth. The securing structure 110 can then be positioned in and/or over the upper portion 18 of the blast hole 10 with the cap member 120 secured to the securing structure 110. The roller stand 170 with the liner roll 160 can also be positioned over the cap member 120 with the tubular liner 150 extending through the liner passage 126 and invertedly secured to the securing structure 110 as previously set forth.

The air compressor 130 can then be coupled to the nozzle 132. Air flow from the air compressor 130 can be controlled manually with a control valve 134 coupled thereto. A pressure gauge 136 can also be coupled to the cap member 120 to determine and evaluate the air pressure while installing the tubular liner 150 in the blast hole 10. Such air pressure can be controlled manually through the control valve 134 to maintain a desired air flow and air pressure within the tubular liner 150.

At this juncture, air can be compressed and/or blown through the nozzle 132 and nozzle opening 124 and against the expanded configuration 152 of the tubular liner 150 as indicated by air flow arrow 138. Such air flow blowing against the expanded configuration 152 of the tubular liner 150 advances the tubular liner 150 through the

liner passage 126 of the cap member 120 in the unexpanded configuration 154 and downward into the blast hole 10. As the tubular liner 150 advances downward, the tubular liner 150 expands radially against the blast hole wall 16. Any air below the tubular liner 150 in the blast hole 10 can be displaced therefrom through the air-relief pipe as indicated by arrows 139.

Turning now to FIG. 4, once the tubular liner 150 has advanced down the blast hole 10, most of the tubular liner 150 is in the expanded configuration 152 and turned inside-out or inverted, except for an end portion 162 that maintains the unexpanded configuration 154 with the sealed tail end 158. As previously set forth, the lower portion 20 of the blast hole 10 will often have ground water 22 collecting and settling at the bottom. The end portion 162 with the unexpanded configuration 154 is configured to sit above the water 22 and be disposed within the expanded configuration 152 of the liner 150 at the lower portion 20 of the blast hole 10. As such, the collected water and moisture is prevented from entering the inside of the tubular liner 150. Further, the radial expanding movement and advancement of the tubular liner 150 down the blast hole 10 substantially prevents puncturing the tubular liner 150 against sharp rocks along the blast hole wall 16. With the tubular liner 150 positioned in the blast hole 10, the cap member (not shown) can be removed from the securing structure 110, after which, the tubular liner 150 can then receive the explosive material (not shown) in the blast hole 10.

In another embodiment, the tubular liner may include a smaller diameter than that of the blast hole. In this embodiment, the tubular liner can be installed into the blast hole as previously described above, but without the air relief pipe. Once the tubular liner is positioned along the length of the blast hole, the tubular liner can be inflated to substantially match the diameter of the blast hole by increasing the air flow with the control valve.

Referring now to FIGS. 4 and 5, explosive material 180 can be poured into the expanded configuration 152 of the tubular liner 150 positioned within the blast hole 10. With the cap member (not shown) removed from the securing structure 110, the securing structure 110 can now be employed as a funnel for pouring the explosive material 180 into the tubular liner 150 disposed in the blast hole 10. As the explosive material 180 reaches the bottom of the tubular liner 150, the unexpanded end portion 162 of the tubular liner 150 moves from being suspended in the water (shown in outline) to a lowered position at the bottom of the blast hole 10. Such is employed by the weight of

the explosive material 180 pulling the unexpanded end portion 162 of the tubular liner 150 downward to the expanded configuration 152 with radial expansion of the tubular liner 150 against the blast hole wall 16 through the lower portion 20 of the blast hole 10. In this manner, the tubular liner 150 is substantially limited in axial movement against the blast hole wall 16, thereby, substantially preventing the tubular liner 150 being dragged against sharp rocks and puncturing the tubular liner 150.

As previously set forth, the tubular liner 150 has a predetermined length with respect to the length of the blast hole 10 so that the unexpanded end portion 162 with the sealed tail end 158 remains at least partially unexpanded and positioned within the tubular liner 150 at the lower portion 20 of the blast hole 10. This is essential in substantially preventing water under hydrostatic pressure from gaining access to the explosive material 180 through the sealed tail end 158. Further, such position of the sealed tail end 158 protects the sealed tail end 158 from stretching and tearing since the sealed tail end 158 is substantially placed in compression by the explosive material 180 compacted therearound at the lower portion 20 of the blast hole 10. As such, by inverting the tubular liner 150 with radial expansion against the blast hole wall 16 and further having the sealed tail end 158 disposed within the expanded configuration 152 of the tubular liner 150, the tubular liner 150 substantially maintains its integrity and provides a sealing barrier from moisture entering the tubular liner 150 and contacting the explosive material 180 therein.

It is to be understood that the above-referenced arrangements are only illustrative of the application for the principles of the present invention. Numerous modifications and alternative arrangements can be devised without departing from the spirit and scope of the present invention while the present invention has been shown in the drawings and fully described above with particularity and detail in connection with what is presently deemed to be the most practical and preferred embodiments(s) of the invention, it will be apparent to those of ordinary skill in the art that numerous modifications can be made without departing from the principles and concepts of the invention as set forth in the examples.